INSTRUMENT AND METHOD FOR DETECTING LEAKS IN HERMETICALLY SEALED PACKAGING

FIELD OF INVENTION

[0001] The invention relates to instrument and techniques for analyzing the oxygen concentration within hermetically sealed packaging, and detecting leaks in hermetically sealed packaging.

BACKGROUND

[0002] Products susceptible to spoilage, such as processed foods, nuts and sliced fruits and vegetables, are often placed in hermetically sealed packaging which has been flushed with an inert gas, such as nitrogen or argon, to achieve an oxygen concentration within the packaging of less than about 3% and thereby prolong the shelf-life of the product. Such packaging is commonly known as controlled atmosphere packaging (CAP) or modified atmosphere packaging (MAP).

[0003] Insufficient flushing of the atmosphere within the packaging and/or leaks in the packaging can significantly reduce the anticipated shelf life, resulting in undesired spoilage. Hence, proper quality control efforts for CAP/MAP typically involve at least periodic testing of packaging to determine the oxygen content within the hermetically sealed packaging and the presence of any leaks in the packaging.

[0004] A variety of instruments and methods for analyzing the oxygen concentration within the headspace of CAP/MAP are known to those skilled in the art, including the PAC CHECK® series of oxygen headspace analyzers offered by MOCON, Inc. of Minneapolis, Minnesota. Briefly, these instruments involve puncturing a sample package with a hollow needle through which a sample of the headspace gases can be withdrawn for analysis by an oxygen sensor. See, United States Patent No. 5,212,993 issued to William Mayer, the disclosure of which is hereby incorporated by reference.

[0005] A variety of instruments and methods are also known for leak detection in hermetically sealed packaging. Leak detection typically involves the creation of a pressure

differential between the pressure inside the packaging (internal pressure) and the pressure outside the packaging (external pressure) - such as by compressing the packaging or pulling a vacuum in the atmosphere surrounding the packaging, followed by the detection of any change in a given variable which could be correlated to the presence of a leak in the packaging. Specific examples include submersion of the packaging into a liquid and detecting any liquid within the packaging (United States Patent No. 6,763,702 issued to Allen Chien et al.), squeezing of the packaging and detecting of any pressure decay (United States Patent No. 6,427,524 issued to Frank Raspante et al.), squeezing the packaging and detecting any volume decay (United States Patent No. 5,533,385 issued to William Frievalt) and placing the packaging within a vacuum chamber and detecting any loss of vacuum (United States Patent. No. 5,150,605 issued to Edwin Simpson).

[0006] While each of these instruments and techniques are generally effective for analyzing the oxygen concentration within hermetically sealed packaging, or detecting leaks in hermetically sealed packaging, a substantial need continues to exist for (i) a quick, easy, inexpensive and accurate instrument and technique for detecting leaks in hermetically sealed packaging, and (ii) an instrument and technique capable of providing both an accurate analysis of the oxygen concentration within hermetically sealed packaging and the detection of any leaks in the hermetically sealed packaging using the same individual package and using a single integrated instrument to conduct both tests.

SUMMARY OF THE INVENTION

[0007] A first aspect of the invention is an instrument for detecting leaks in hermetically sealed packaging. The instrument includes (a) a needle having a lumen, (b) a mass flow rate sensor, and (c) a vacuum pump. The mass flow rate sensor is in sealed fluid communication with the lumen defined by the needle. The vacuum pump is in fluid communication with both the lumen defined by the needle and the mass flow rate sensor for evacuating gas from the hermetically sealed packaging and allow the mass flow rate sensor to sense any continuing mass flow from the evacuated packaging.

[0008] A second aspect of the invention is an instrument for analyzing oxygen concentration of a gas within hermetically sealed packaging and detecting leaks in the hermetically sealed packaging. The instrument includes (a) a needle having a lumen, (b) an

oxygen sensor, (c) a mass flow rate sensor, and (d) a vacuum pump. The oxygen sensor and the mass flow rate sensor are in sealed fluid communication with the lumen defined by the needle. The vacuum pump is in fluid communication with the lumen defined by the needle and both the oxygen sensor and the mass flow rate sensor for (A) pumping a sample of a gas from within a hermetically sealed packaging through the lumen of the needle and into operable contact with the oxygen sensor for permitting sensing of an oxygen concentration of the sample, (B) evacuating the gaseous content of the hermetically sealed packaging, and (C) allow the mass flow rate sensor to sense any continuing mass flow from the evacuated packaging.

[0009] A third aspect of the invention is a method of detecting leaks in hermetically sealed packaging. The method involves (a) selecting a hermetically sealed packaging, (b) puncturing the hermetically sealed packaging with a hollow needle having a lumen, (c) evacuating any gaseous content from within the hermetically sealed packaging through the lumen of the needle to form a vacuum within the hermetically sealed packaging, and (d) measuring mass flow rate from within the evacuated hermetically sealed packaging. Sensing of a mass flow rate from the evacuated hermetically sealed packaging above a threshold value indicates a leak in the hermetically sealed packaging.

[0010] A fourth aspect of the invention is a method of analyzing oxygen concentration of a gas within hermetically sealed packaging and detecting leaks in the hermetically sealed packaging. The method involves (a) selecting a hermetically sealed packaging, (b) puncturing the hermetically sealed packaging with a hollow needle having a lumen, (c) pumping a sample of the gas within the hermetically sealed packaging through the lumen of the needle and into operable contact with an oxygen sensor for sensing the oxygen concentration in the sample, (d) evacuating the gaseous content from within the hermetically sealed packaging through the lumen of the needle to form a vacuum within the hermetically sealed packaging, and (e) measuring mass flow rate from the evacuated hermetically sealed packaging. Sensing of a mass flow rate from the evacuated hermetically sealed packaging above a threshold value indicates a leak in the hermetically sealed packaging.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is a side view of one embodiment of the invention.

[0012] Figure 2 is an enlarged cross-sectional side view of the distal end of the needle shown in FIG 1.

DETAILED DESCRIPTION OF THE INVENTION INCLUDING A BEST MODE

Nomenclature

10	Instrument
20	Needle
21	Distal End of Needle
29	Lumen of Needle
30	Pressure Sensor
40	Oxygen Sensor
50	Valve
60	Vacuum Pump
70	Mass Flow Rate Sensor
80	Collective Reference to Tubing 80a, 80b and 80c
80a	Length of Tubing Interconnecting the Needle and the Oxygen Sensor
80b	Length of Tubing Interconnecting the Oxygen Sensor and the Vacuum Pump
80c	Length of Tubing Interconnecting the Vacuum Pump and the Mass Flow Rate Sensor
90	Vent
100	Packaging
101	Solids Content of Packaging
102	Gaseous Content of Packaging
200	Septum

Structure

[0013] As shown in FIG. 1, a first aspect of the invention is an instrument **10** for analyzing the oxygen concentration of the gaseous content **102** of hermetically sealed packaging **100** and detecting leaks in the hermetically sealed packaging **100**.

[0014] The instrument **10** can be effectively employed with a wide variety of hermetically sealed packaging **100** ranging from rigid packaging such as poly vinyl chloride tubes, through semi-flexible packaging such as wax-coated cartons and thin-walled polyethylene bottles, to flexible packaging such as bags made from polyethylene terephthalate (*i.e.*, MYLAR®) or polyethylene films.

[0015] Referring to FIG. 1, the first aspect of the instrument **10** includes a needle **20**, a pressure sensor **30**, an oxygen sensor **40**, an optional valve **50**, a vacuum pump **60**, a mass flow rate sensor **70**, and appropriate tubing **80a**, **80b** and **80c** (hereinafter collectively referenced as tubing **80**) for sealingly interconnecting the various components of the instrument **10**.

[0016] As shown in FIG. 2, the needle **20** is configured and arranged with a lumen **29** and a sharp pointed distal end **21** effective for piercing a sidewall (unnumbered) of the packaging **100**. A septum **200** is preferably adhered to the sidewall of the packaging **100** - especially when the packaging **100** is highly flexible - prior to piercing of the packaging **100** with the needle **20** in order to maintain a hermetic seal around the needle **20**.

[0017] Referring to FIG. 1, a vacuum pump **60** is sealingly connected to the lumen **29** of the needle **20** by tubing **80**. Once the needle **20** has been inserted through packaging **100**, operation of the vacuum pump **60** is effective for pulling a sampling of the gaseous content **102** of the packaging **100** out from the packaging **100** through the lumen **29** of the needle **20** and into operable contact with an oxygen sensor **40**.

[0018] Substantially any type of vacuum pump **60** is suitable for use in the instrument **10**, with selection dependent primarily upon choice of power source (*i.e.*, battery or electrical power lines), desired level of portability (*i.e.*, hand-held or desk-top), and intended use (*i.e.*, testing of large volume or small volume packaging). For most applications, a vacuum pump **60** with a maximum gas volumetric flow rate of about 250 to 1,000 cm^3/minute and capable of pulling a maximum vacuum of about 1-15 lb/in^2, preferably 4-8 lb/in^2, using standard consumer batteries (*e.g.*, AAA, AA, A, C, D or 9-volt batteries) will be sufficient.

[0019] The oxygen sensor **40** may be selected from any of a wide variety of oxygen sensors readily available from a number of sources, such as the PAC CHECK® series of

oxygen headspace analyzers offered by MOCON, Inc. of Minneapolis, Minnesota. The oxygen sensor **40** is preferably positioned upstream from the vacuum pump **60** to avoid potential contamination of the gas sample taken from the packaging **100** for analysis.

[0020] As described in detail in United States Patent No. 5,212,993, the disclosure of which is hereby incorporated by reference, a valve **50**, such as a 3-way valve, is preferably positioned between the oxygen sensor **40** and the vacuum pump **60** for permitting the pressure of a gas sample pulled from the packaging **100** into the oxygen sensor **40** by the pump **60** to be normalized prior to analysis. Such normalization of the gas sample pressure has been found to enhance the accuracy of the analysis.

[0021] A mass flow rate sensor **70** is positioned downstream from the vacuum pump **60** for measuring the mass flow rate of the gaseous content **102** pulled from packaging **100** by the vacuum pump **60**. Alternatively, the mass flow rate sensor **70** may be positioned upstream from the vacuum pump **60**. Of interest is the mass flow rate measured by the mass flow rate sensor **70** after the gaseous content **102** has been evacuated from the packaging **100** by the vacuum pump **60** and a steady state vacuum has been established within the packaging **100**. The mass flow rate measured at this stage is indicative of the presence of a leak in the packaging **100** when the mass flow rate is greater than or equal to a threshold value and indicative of the absence of any leaks in the packaging **100** when the mass flow rate is less than the threshold value.

[0022] Selection of a practical threshold value depends upon a number of factors including the level of the vacuum pulled by the vacuum pump **60**, the material from which the packaging **100** is constructed, etc. Generally, a threshold value of about 0.1 cm^3/min may be effectively employed as the threshold value when the vacuum pulled by the vacuum pump **60** is between about 4-8 lb/in^2.

[0023] Suitable gas mass flow rate sensors **70** for use in the instrument **10** are available from a number of sources, including MKS Instruments or Wilmington, Massachusetts.

[0024] A pressure sensor **30** is employed between the needle **20** and the vacuum pump **60**, preferably between the needle **20** and the oxygen sensor **40**, for measuring and reporting the pressure within the packaging **100** while the vacuum pump **60** is operating.

[0025] The pressure sensor **30**, oxygen sensor **40**, optional valve **50**, vacuum pump **60**, and mass flow rate sensor **70** are preferably operably interconnected through a microcontroller or processor (not shown) for controlling operation of the various components, and receiving and processing the data signals generated by the various sensors. These components, along with the associated tubing **80** and a power source (not shown), are preferably retained within a single housing (not shown) which is equipped with (i) an inlet port (not shown) configured and arranged to attach to a length of tubing **80a** in order to place the needle **20** into fluid communication with the components retained within the housing, and (ii) a user input device (not shown) and a visual display panel (not shown) for communicating with a user.

[0026] The instrument **10** may be constructed as a portable or desktop unit.

Use

[0027] A unit of packaging **100** having a solids content **101** and a gaseous content **102** is selected for analysis. A septum **200** is optionally adhered to the outer surface (unnumbered) of the packaging **100**. The septum **200** and packaging **100** are perforated by the distal end **21** of the needle **20** a sufficient distance to place the lumen **29** into fluid communication with the interior contents of the packaging **100**. The needle **20** is then left in the inserted position for the balance of the procedure. The balance of the procedure may be effected manually or automatically. The following disclosure shall be presented based upon automated operation of the instrument **10**.

[0028] A user initiates analysis by pressing a START button (not shown). The valve **50** is actuated so as to place the needle **20** into fluid communication with the vacuum pump **60** and close the vent **90**. Vacuum pump **60** is then activated to pull a sample of the gaseous content **102** from the packaging **100** into the oxygen sensor **40** through the length of tubing **80a**. Typically a sample of about 2-5 ml is sufficient. The vacuum pump **60** is then deactivated, the valve **50** actuated to open the vent **90** and allow the pressure of the gaseous sample within the oxygen sensor **40** to be normalized. Once the pressure of the gaseous sample is normalized the valve **50** is actuated to close the vent **90** and the oxygen sensor **40** is

activated to sense, record and report the oxygen concentration in the gaseous sample withdrawn from the packaging **100**.

[0029] Upon completion of the analysis performed by the oxygen sensor **40**, the oxygen sensor **40** is deactivated and the vacuum pump **60** activated to evacuate the gaseous content **102** from the packaging **100** and pull a vacuum. The mass flow rate sensor **70** is activated and the mass flow rate through the tubing **80** is sensed after the gaseous content **102** from the packaging **100** has been evacuated. The sensed mass flow rate may simply be recorded and reported, but is preferably first compared to a threshold value and the sensed mass flow rate recorded and reported along with an indicated of NO LEAK DETECTED when the mass flow rate at steady state vacuum is less than the threshold value, or an indication of LEAK DETECTED when the mass flow rate at steady state vacuum is greater than or equal to the threshold value. The vacuum pump **60** and mass flow rate sensor **70** are then deactivated.